Reponse to Reviewers' Comments
July 24, 2002, Review of NuMI Beam Monitoring System

Sacha Kopp, Debbie Harris
WBS 1.1.5 Level 3 Managers

The NuMI project conducted a review of WBS1.1.5, the Neutrino Beam Monitoring system, on July 24, 2002. The topics of this review were:

1. design of the muon and hadron monitoring chambers
2. the ability of these chambers to withstand the anticipated radiation levels and ambient environments
3. the mounting and alignment stands for these systems
4. personnel safety during detector installation and repair

The reviewers were supplied written documentation: NuMI notes 845-849 covered all these topics.

Prior to the review an error was discovered in the calculated necessary shielding thickness to safely remove a failed hadron monitor. As noted by several reviewers, the procedures therefore require further development to accomodate this greater shielding. Subsequent to the review, NuMI project management determined that the hadron monitor, its primary role being a commissioning device, need not be replaced if it fails. The potential but non-essential utility of the hadron monitor post-commissioning, as well as the potential need to recommission the beam after a long shutdown, may require the replacement of a failed detector. Therefore, the decision was made to require the means to replace it, but not require at this time the specifications for the replacement and personnel shielding during such replacement.

We would like to thank our reviewers for the careful and critical comments provided during this review. The expertise brought to this review from all parts of the lab was extremely beneficial, and we greatly appreciated all the consultations with the reviewers even prior to the review. The many suggestions and descriptions of past experience were quite valuable.

Below, we give specific replies or actions taken in response to reviewer comments.

Replies to Mike Andrews

1. no written comments given

Replies to Dave Pushka

1. We agree with the overall comment that the stands are more complex than necessary. Indeed, the fabrication cost (after revisions noted below) is now $6000 materials and $13,000 machine shop, not much more than the $10,500 cost for construction drawings.
   (a) We agree with the comment that the kinematic mounts are expensive and unnecessary. These have been removed from the design. The total cost savings for three alcoves is $6000, although the cost to revise the design from PSL was an additional $1500.
   (b) The three point support was retained so as to not incur additional design expense (see note above).
   (c) We were concerned with the additional safety risks associated with working underground in general and wanted to make sure the support structure would withstand any mishaps.
2. The hadron monitor design is now complete and significantly advanced since the review. The major design features have been retained, although the detector mass has been reduced from 60 lbs to 48 lbs.
3. The rail design was retained as presented. The complex feature is a jack that is available in a catalog, and the expense is minimal. It was thought convenient to be able to jack the monitor to the final required position, alleviating the precision required of the crew who will bolt the rail support into the concrete. Regarding the stability along the axis of the beamline, we thought the rail was adequate, since the monitor is constrained by the roller which wraps around the lower rail, and by the fin which is captured by the upper rail.
4. The handling of the activated detector indeed requires substantially greater work. It is hoped to devote time to this design and procedure in the future. The complexity of the line dance, however, should not be underestimated.

Replies to Mike Gerardi

1. we agree hadron monitor disposal requires further safety precautions. As mentioned above, this disposal is not going to be addressed in the near term.

2. The monitor alignment tolerance of ~ 1 cm was set to allow replacement of a detector tube with minimal impact on the measured spatial distribution of muons in an alcove. Thus, the comment that 'realignment ... greatly affect muon rates and positions in the alcoves' should be addressed by our alignment spec.

3. the ion tray alignment was specified – the requirement is 1 cm and will easily be achieved. Construction tolerances are of order 1-2 mm and survey alignment may be accomplished to within 1 mm. The support stands will readily accomodate 1 mm placement accuracy. The sole alignment issue is the proper fiducialization of the muon alcoves with respect to the overall beamline geometry. This latter aligment is thought to be good to better than 2.5 cm, which set our 1 cm detector replacement spec.

4. Muon monitor replacement behind the absorber will expose personnel to the residual radiation around the absorber stack. The rate at the concrete is calculated by A. Wehmann to be ~ 20 mRem/hr on contact. The muon monitors are several meters from the absorber. At worst, personnel would require 1 hour to replace a monitor (4 bolts, two electronics cables, and two Swagelok-connected gas lines, and no survey really necessary), so dose will be limited to under 20 mRem/person, for no more than two people.

5. The hadron monitor heating was documented in NuMI-B-846. No further studies were thought warranted, given that the heating is less than 20°C over ambient under the most unrealistic assumptions. Further, a more focused beam was impinged on a detector at the Fermilab Booster, and no ill effect was noted.

6. Dose rates in the alcoves for the low energy beam are documented in NuMI-B-845. The highest dose is 5 MRad/year in the first plane. In the ME and HE beams, the highest particle fluxes are still in the first alcove (behind the dump) and will be less than a factor 2 greater in magnitude (see the plot prepared by D.Harris and presented by S.Kopp at the NBI02 workshop, `www.hep.utexas.edu/~kopp/minos/beamon/`). Hence, we expect less than 10 MRad/year in any beam configuration. Our detector design for the muon monitors would be expected to perform well up to the 1 GRad level.

7. It is difficult to define regions of access during beam on. Hence the locations of gas and electronics racks have been chosen to be outside the fire door in the access passage so as to allow beam-on access.

Replies to Pat Hurh

1. General

    (a) The detector designs are complete and fabrication is well-underway.

    (b) Radiation damage tests were completed at the UT Nuclear Engineering Teaching Reactor, a 1 MW facility. A dose of 12 GRad was delivered to ceramic circuit board, a ceramic feedthrough, ceramic putty, PEEK plastic, a segment of kapton coax cable and an aluminum swagelok connector. For pictures, see `www.hep.utexas.edu/~kopp/minos/beamon/meetings/dec02_plenary.pdf`. While the other components performed quite well, the putty disintegrated. Consequently, a new cover was developed for the rear of the Hadron Monitor feedthroughs to cover the signal connectors, see `http://www.hep.utexas.edu/~kopp/temp/3D_ISI_peek_guard_un5-8deg_solid.jpg`. It was interesting to note that the kapton cable did quite well and still was flexible, did not crack, and held off 1000 V. This fact allowed us to reduce the ceramic thickness of the homemade ceramic cables in the rear of the Hadron Monitor.

    (c) The Hadron Monitor replacement procedure will be deferred to a post-project date.

    (d) See responses to Dave Pushka above.

2. Muon Monitor

    (a) The number HV feedthroughs was retained. It was thought beneficial in the case of failure of one pad within the tube.

    (b) We relaxed the 1 mm tolerance to 5 mm.

    (c) The PEEK caps no longer need provide compression. The ceramic ion chamber plates now have a pad on their rear which is used to solder the support post to the plate, providing mechanical contact. The PEEK caps now simply must thread over the post to act as a cover against ion drift. See photos in `www.hep.utexas.edu/~kopp/minos/beamon/meetings/dec02_plenary.pdf`.

    (d) This suggestion was made again because of the worry of the strength of the PEEK caps. In the new design the two pieces are soldered, precluding the need for self-locking screw threads.

    (e) This part of the design was retained. Revisions were getting costly.

    (f) See above response.

    (g) The kinematic mounts were removed, and the inaccessibility noted was a misunderstanding which was my fault. The nut in question is welded to the channel.

    (h) The weight of the final weldments will be quite similar to that presented.

    (i) This was an excellent comment. We think the adaptor plate should now repeat the location of a new tube onto the studs which are mounted on the support stand.

3. Hadron Monitor

   (a) This bulkhead was adopted and appears to work very well. See photos in `www.hep.utexas.edu/~kopp/minos/beamon/meetings/dec02_plenary.pdf`.
   (b) This has not been done. Seals are currently holding $< 10^{-5}$ ml/sec, but potential leaks developing in the beam have not been thought through.
   (c) We opted for no nut at all, but rather a solder mount, as mentioned above.
   (d) The front lid has been increased in thickness to 1/16".
   (e) This has not been done yet. It will be investigated.
   (f) This has not been done yet.
   (g) Yes.
   (h) The removal procedure will be investigated in the future.

Replies to Jim Hylen

1. This is indeed not settled, and Kamran Vaziri from ES&H, who earlier thought the extrapolation factors, which were derived from a paper by Rokhno, Grossman, et al, were fine now thinks they are too optimistic. See his comments on the review web site. No work has been done to revisit this, since we have deferred issues related to Hadron Monitor replacement.

2. Again, deferred.

3. The roller was reduced in size so as not to contribute much additional mass. In the worst case, it will act as a slide. It was already fabricated.

4. Again, deferred.

5. The measurements of neutron-induced signals have been worked on extensively in the months since the review. The 'negative' signals were traced to contact potentials, and the subject of contact potentials motivated some study of the materials used in the readout path of the chambers. More recent tests with our first muon monitor tube reveal no contact potential effects. Consequently, we plan to leave the HV polarity as originally specified (a key point, since PREP does not have many (-) Droege supplies in stock).

6. The kinematic mount was dropped.

7. This was a misunderstanding I caused during the review. The nut that is pictured is welded to the frame, so the threaded post simply threads up into it.

8. The tooling balls are being located on the support brackets which join the endflanges of the tube to the studs on the support stands. This was done because the endplates were already in fabrication by the time we got around to thinking about this.

9. Our own studies of prototype chambers reveal no persistent O_2 levels at the 10 p.p.m. level after a few days of flushing. Our prototypes have larger trapped volumes in feedthroughs made of PEEK tubing surrounding a threaded post acting as the connector pin.

10. We opted to plate the back side of the signal plate with a ground plane. The extra cost was \$3/chamber, so a mere \$1000 increase to the overall cost of the system. The HV plate was not given a ground plane, since charge collection on its back side would not lead to spurious signal, and since we thought dielectric failure of the ceramic more likely than this failure mode.

11. Agreed. 1/16”

Replies to Kamran Vaziri

1. The apparent problems with our geometry factors has led us to revisit the mass of the hadron monitor design. We have been able to reduce the stainless steel content from 7 lbs to under 2 lbs. We now believe the on-contact number to be 20 Rem/hr, so the 10 ft geometry factor of 1% noted by Kamran now leads to 200 mRem/hr at 10 ft, still a sizeable amount.

2. Agreed, but as noted, we have not returned to this subject.

3. See replies to Mike Gerardi’s comments

4. We have studied this using an intense neutron source only. No visible effect was visible at a level as large as 0.05 times the charged particle signal. No similar test was readily available at the Booster, since the RDF group was most concerned with minimizing material in the beam.

5. This is apparently a misprint. In NuMI-B-846, pg. 10, we have a table calculated using a spreadsheet obtained from Nancy Grossman. The one-week cooldown for Aluminum is a factor of 50, and that factor was used in calculating the numbers presented in the note.